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SAP2DC DOCUMENTATION (VAX-11/750 VERSION) - AN INTERFACE PROGRAM FOR THE FINITE ELEMENT PROGRAM SAP2D

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by

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ABSTRACT

SAP2DC is one of the component programs contained in the *SAP2D* system. It merges additional card or card image input with the output that have been generated by the program MSHGEN and produces an input file which will be acceptable to the finite element program SAP2D.

This report documents SAP2DC. In particular, the files used and the input instructions required are described.

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DOCUMENTATION SUR LE SAP2DC (VERSION DU VAX-11/750) - PROGRAMME D'INTERFACE POUR LE PROGRAMME D'ANALYSE PAR ÉLÉMENTS FINIS SAP2D

par

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RÉSUMÉ

Le SAP2DC est l'un des programmes qui sont contenus dans le système SAP2D. Il fusionne les entrées supplémentaires de cartes ou d'images de cartes avec les sorties produites par le programme MSHGEN et produit un fichier d'entrée qui sera accetable avec le programme d'analyse par éléments finis SAP2D.

Le présent rapport fournit des renseignements sur le SAP2DC, en particulier sur les fichiers utilisés et sur les instructions d'entrée requises.

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1.0 INTRODUCTION

MSHGEN [1]* program produces only part of the data (nodal data, element data and pressure data) required by the finite element program SAP2D[2, 3]. Other necessary SAP2D information such as material properties, initial stresses and concentrated forces are absent. SAP2DC merges this additional card or card image information with the output (GENOUT) of MSHGEN to produce an input file (SAPIN) acceptable to SAP2D.

SAP2DC has been modified to accommodate the input of initial stresses. However, it is not capable of producing a fully general input file for SAP2D. The following restrictions apply:

a) no thermal effects;

b) only one load case;

b) no boundary elements; and

b) gravity loads, if any, occur in (-Z) direction.

2.0 FILE USAGE

Four files are used on SAP2DC. These are as follows :-

Logical file name	Description
FOR005	SAP2DC input data file (input);
FOR006	The SAP2DC print file (output);
GENOUT	The file contains the mesh data generated by MSHGEN (input).
SAPIN	The file contains the SAP2D input (output). SAP2DC takes GENOUT and merges with additional information, which will be described below, and produces a file - SAPIN which is acceptable by the program SAP2D.

* Number(s) refer to cited references

3.0 INPUT INSTRUCTION

a) Card No.1 : Title or Heading

READ (,*)† TITLE

TITLE — 80 character title. Default - if card is blank then the MSHGEN title card is used.

b) Card No. 2 : Control Card

READ (,*) NP, NRES, IMAT, ICF, ICOMP, SCALE

NP — Type of structure indicator.
NP = 0, plane strain;
NP = 1, axisymmetric; and
NP = -1, plane stress.

NRES — Initial stress indicator. If NRES is nonzero, initial stresses need to be specified and SAP2D will attempt to calculate initial stresses using the subroutine CALRS4. For the present version the initial stresses are assumed to vary linearly in the Z - direction. However, the user can modify subroutine CALRS4, if required, to account for any anisotropic effect. If NRES is zero, the program will set initial stresses to zero and input will not be required.

IMAT — Anisotropic material properties indicator. If IMAT=0 then all materials are assumed to be isotropic. If IMAT is not equal to zero then one or more materials have anisotropic properties.

ICF — Concentrated force indicator. If ICF=0 then no concentrated forces are input. If ICF is nonzero then concentrated forces are input.

ICOMP — Incompatible mode indicator. If ICOMP is nonzero then incompatible modes are suppressed in calculating the stiffness matrices in SAP2D. If the structure is axisymmetric, incompatible modes are always suppressed.

SCALE — Coordinate scaling factor. MSHGEN generated coordinates are multiplied by SCALE.
Default value for SCALE is SCALE = 1.

† Note : Denotes free format

c) Card No. 3 : Printer Control Card

READ(,*) NPRINP, NPRDIS, NPRSTR

NPRINP — Input print indicator. If nonzero, the printing of input data will be suppressed in SAP2D.

NPRDIS — Displacement print indicator. If nonzero, the printing of SAP2D displacement output will be suppressed.

NPRSTR — Stress print indicator. If nonzero, the printing of SAP2D stress output will be suppressed.

d) Block of Cards Defining Material Properties:

If IMAT = 0 (isotropic material properties), then there are 'NUMMAT' cards to be input.

READ(,*) N, E, RNU, WGT

N — Material number.

E — Young's modulus or modulus of deformation.

RNU — Poisson's ratio.

WGT — Weight density.

If IMAT is not equal to 0 (anisotropic material properties), then there are a total of "3×NUMMAT" cards to follow assuming that the number of temperature card (NTC(MAT)) which defines the material is 1. The format and content of these cards are identical to that given in SAP2D.

With each material there is associated 3 cards:

First Card

READ(,*) MAT, NTC(MAT), WGT(MAT), WANG(MAT)

MAT — Material number.

NTC(MAT) — The number of temperature cards defining this material. The default value is 1.

WGT(MAT) — The weight density of this material.

WANG(MAT) — The angle of anisotropy with respect to the Y or R axis.

Second Card

READ(,*) EN, ES, ET, RNUNS, RNUNT, RNUST, GNS

EN	—	Young's modulus in N-direction.
ES	—	Young's modulus in S-direction.
ET	—	Young's modulus in T-direction.
RNUNS	—	Poisson's ratio associated with N-S directions.
RNUNT	—	Poisson's ratio associated with N-T directions.
RNUST	—	Poisson's ratio associated with S-T directions
GNS	—	shear modulus in N-S direction.

Third Card

READ(,*) HAN, HAS, HAT

HAN	—	Coef. of thermal expansion in N direction.
HAS	—	Coef. of thermal expansion in S direction.
HAT	—	Coef. of thermal expansion in T direction.

e) Block of Cards Defining the Initial Stresses

If NRES .EQ. 0, then initial stresses are not required. Otherwise, the initial stresses need to be input. The initial stresses are assumed to vary linearly in the direction of Z. The stresses are defined as follows:

σ_{YY} or σ_{RR} = AYY + BYY × Z

σ_{ZZ} = AZZ + BZZ × Z

σ_{XX} or σ_{TT} = AXX + BXX × Z

σ_{YZ} or σ_{RT} = AYZ + BYZ × Z

A typical example to evaluate these stress coefficients is given in Figure 1. Note that the stresses calculated from the above equations must be compatible with the load (internal and external) applied to the system.

A total of 4 cards are required to define these stress coefficients.

READ(,*) AYY, BYY

READ(,*) AZZ, BZZ

READ(,*) AXX, BXX

READ(,*) AYZ, BYZ

Notes :

1. If IMAT .NE. 0, then the material properties of all materials must be entered in SAP2D format even if some of the materials are isotropic.
2. Material property and concentrated force data are not checked by SAP2DC, *i.e.*, the whole card is merely listed and transferred to the SAP2D input file.
3. NUMMAT - the number of different materials is transferred fron MSHGEN.

4.0 COMMAND PROCEDURE

When the major portion of the input data for the program SAP2D is generated by the program MSHGEN, the MSHGEN output file - GENOUT is then merged with additional card or card immage data which resides on the logical unit FOR005, and a file is produced which will be acceptable by SAP2D. This logical file is referred as SAPIN.

The usual procedure is to create GENOUT file by running the program MSHGEN; if the finite element mesh generated by MSHGEN is satisfactory, then the interface program SAP2DC is run with the finite element program SAP2D. Therefore, this is usually accomplished by executing the SAP2D command procedure. This procedure has been described in SAP2D documentation [2].

5.0 SAMPLE INPUT

5.1 MSHGEN Input:

For completeness, the input data for MSHGEN (mesh generating) program, as shown in Table 1, is included here for reference. The finite element model is illustrated in Section 5.3.

Table 1 - MSHGEN input data

```
'TWO 5M BY 14M STOPES SEPARATED BY A 5M BY 10M PILLAR'
28 8 3 3 1 0
5 10 15
20 5 20
1 3 0. 0.
2 2 5. 0.
3 2 19. 0.
4 3 100. 0.
5 1 0. 100.
6 0 5. 100.
7 0 19. 100.
8 1 100. 100.
9 1 0. 105.
10 0 5. 105.
11 0 19. 105.
12 1 100. 105.
13 1 0. 205.
14 0 5. 205.
15 0 19. 205.
16 1 100. 205.
17 2 40. 0.
18 1 0. 70.
19 0 5. 70.
20 0 19. 70.
21 1 100. 70.
22 0 40. 100.
23 0 40. 105.
24 1 0. 132.
25 0 5. 132.
26 0 19. 132.
27 1 100. 132.
28 0 40. 205.
```

– Table 1 continued –

1 1 2 6 5 0 19 0 18 1 0 0
2 2 3 7 6 0 20 0 19 1 0 0
3 3 4 8 7 17 21 22 20 1 0 0
4 5 6 10 9 0 0 0 0 1 0 0
6 7 8 12 11 22 0 23 0 1 0 0
7 9 10 14 13 0 25 0 24 1 0 1
3 10.665 10.665
8 10 11 15 14 0 26 0 25 1 0 1
3 10.665 10.665
9 11 12 16 15 23 27 28 26 1 0 1
3 10.665 10.665

5.2 SAP2DC Input Data:

An example input for SAP2DC is shown in Table 2. Note that the coefficients relating the initial stresses must be compatible with the load applied to the system.

Table 2 - SAP2DC input data

```
Two 5M by 14M Stopes Separated by a 5M by 10M Pillar
0 1 0 0 1 1
0 0 0
1 7.5E+5 .26 .027
-32.5350 0.054
-16.2675 0.027
-12.6887 0.0211
0.0 0.0
```

5.3 Finite Element Model:

Figure 1 shows a key zone diagram. Note 1, following this figure, on the following page, demonstrates the evaluation of initial stress coefficients for this model. The origin of the coordinate system, in this example, is located at the lower left corner of the model.

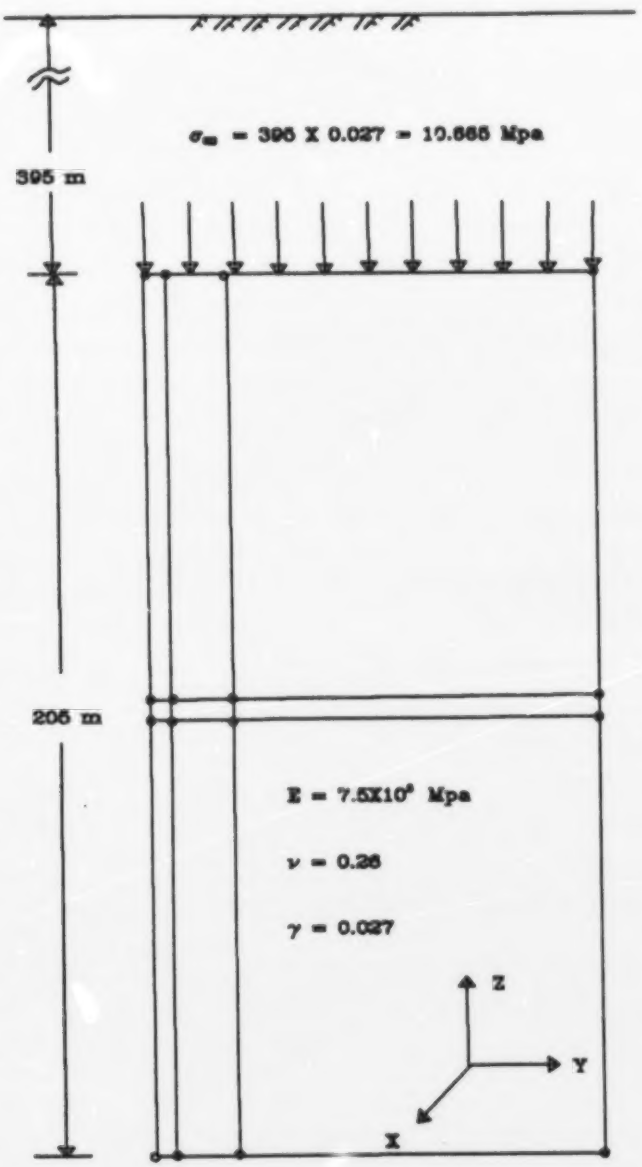

Figure 1. Finite Element Model (Zone Diagram).

– Figure 1 continued –

Note 1 : Stress Coefficient Evaluation

The stress field is assumed to vary linearly with depth, *i.e.*, in the direction of Z as shown in Figure 1.

$$\sigma_{ZZ} = A_{ZZ} + B_{ZZ} \times Z$$
$$\sigma_{YY} = A_{YY} + B_{YY} \times Z$$
$$\sigma_{XX} = A_{XX} + B_{XX} \times Z$$

Assuming that the vertical stress 'σ_{ZZ}' is due to gravity only, then we have at the top of the model:

$$10.665 = A_{ZZ} + B_{ZZ} \times (205.0)$$

at the bottom of the model:

$$16.200 = A_{ZZ} + B_{ZZ} \times (0.0)$$

Therefore:

$$A_{ZZ} = 16.200$$
$$B_{ZZ} = -0.027$$

And we assume $\sigma_{YY} = 2\sigma_{ZZ}$ and $\sigma_{XX} = \nu(\sigma_{YY} + \sigma_{ZZ})$ where ν is Poission's ratio.

Then we have:

$$\sigma_{YY} = 32.400 - 0.054 \times Z \quad \text{and}$$
$$\sigma_{XX} = 12.636 - 0.021 \times Z$$

Therefore:

$$A_{YY} = 32.400$$
$$B_{YY} = -0.054$$
$$A_{XX} = 12.636$$
$$B_{XX} = -0.021$$
$$A_{YZ} = B_{YZ} = 0.0$$

6.0 REFERENCES

1. Toews, N.A., Yu, Y.S. and Wong, A.S.; "MSHGEN documentation (VAX-11/750 Version) - A mesh generating program for finite element analysis of two dimensional structures"; Division Report MRP/MRL 85-32 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; February 1985.

2. Toews, N.A., Yu, Y.S. and Wong, A.S.; "SAP2D documentation (VAX-11/750 Version) - A 2-D linear elastic finite element computer system"; Division Report MRP/MRL 85-35 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; March 1985.

3. Toews, N.A. and Yu, Y.S; "SAP2D documentation (1975 version) 2-D linear elastic finite element computer system"; Division Report MRP/MRL 75-109 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; December 1985.